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(54) ELECTRICAL POWER CONVERSION APPARATUS

(71) We, N.V. NEDERLANDSE GASUNIE, a Netherlands Limited Liability Company of P.O. Box 19, Groningen, the Netherlands, do hereby declare the invention,

for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to an electrical power conversion apparatus for feeding one or more separate circuits, and of a kind comprising a first transformer the primary winding of which can be connected to an alternating current power source of a frequency of 50 or 60 cps a.c. voltage, a rectifier circuit connected to the secondary winding of said first transformer, a generator connected to said rectifier circuit for generating an alternating current having a higher frequency than that of said alternating current power source, and a second transformer the primary winding of which is connected to said generator and having one or several separate secondary windings, which, or each of which, is connected to a separate second rectifier circuit for providing a direct current output voltage.

A circuit of this kind is known from the U.K. Patent 1,309,661, in particular Figure 3c; the embodiment of the circuit there indicated is meant for use in television sets. In the U.K. Patent 1,325,031 such a circuit is considered to form part of the known state of the art.

In certain applications, for example when an electrical power conversion apparatus of the type referred to is to be used to feed sensitive electrical equipment such as measuring instruments, and notably to feed measuring or control equipment installed in an explosive gaseous environment, it is desirable to provide complete galvanic separation of the mains input and the earth from the output circuit and a low capacitive coupling between the mains or earth and the equipment fed by the converter circuit via parts of the circuit and/or equipment to ensure a high interference suppression of interferences which may be present in the mains; also it may be desirable to provide several output power sources in a simple manner.

To this purpose according to the invention, there is provided an electrical power conversion apparatus of the kind hereinbefore referred to, which is characterized in that said alternating current having a higher frequency than said alternating power source has a frequency ranging between 20 to 80 kHz.; the said second transformer comprises a ferrite loop core having first and second portions located opposite one another, said primary winding of the second transformer being positioned on said first loop portion; and there is at least one printed output circuit which includes a said secondary winding of said second transformer in the form of a spiral disposed in a plane perpendicular to said second loop portion, and which serves to rectify, ,smooth and stabilise the high frequency current, said output circuit incorporating one or more resistors providing a resistance of at least 100 ohms and having at its output terminals a capacitance and self-inductance of not more than 2 μF and 10 mH respectively.

An embodiment of the invention will be described with reference to the accompanying drawings in which:

Figure 1 is a diagram of a circuit according to the invention;

Figure 2 is a diagrammatic plan view of the output transformer with a few printed output circuits; and

Figure 3 is a side view of the transformer of Figure 2.

According to the Figure 1 diagram the circuit consists of one transformer 1, which can be connected to a 50 or 60 cps mains and to the secondary winding of which a rectifier 2 is connected. The transformer 1 is preferably a so-called ferro-resonant transformer, in which primary voltage variations result in only relatively small secondary voltage variations. Constant-voltage transformers of this kind are commercially available. The smoothed output d.c. voltage of the rectifier 2 is supplied to a generator circuit 3, which

generates an a.c. voltage having a frequency that lies preferably between 20 and 80 kilocycles, for instance 50 kilocycles. Said a.c. voltage is supplied to the primary winding 5 of a transformer 4, which is provided with a number of secondary windings 6, 6', 6''; each secondary winding 6 is connected with a rectifying, smoothing- and stabilizing-circuit 7, 7' and 7''.

In the Figures 2 and 3 the way in which the parts 5 to 7 inclusive are combined into a whole is shown in detail. The magnetic circuit of the transformer 4 has the shape of a rectangle and is comprised of two parts 8 and 9 which consist of ferrite material, are preferably identical and rest against one another by the faces 10 and 11. The two sides A and B of the rectangle in which the constituent faces 10 and 11 are located form the core parts of the transformer, the other sides C and D forming two yokes which connect these core parts. On the one core part A the primary winding 5 is placed, whilst a number of secondary windings 6 may be slid on the other core part B, as required. In this embodiment, each winding 6 is applied in the form of a printed spiral coil to a circuit panel 12, on which also the circuit indicated by the number 7 in Figure 1 is accommodated. The parts of this circuit are the following: a rectifier 13 (for instance a rectifying bridge circuit, made up of 4 diodes, for full wave rectifying), a capacitor 14, a resistor 15, a capacitor 16, a voltage stabilizer 17, and a capacitor 18. The resistor 15 has the function of a current limiting resistor and also forms part of the smoothing filter formed by the capacitors 14, 16 and 18. The rectifier 13 and the stabilizer 17 are commercially available in the form of small integrated circuit blocks that can be mounted on the circuit panel, of course, they may also be built from discrete components.

Example

A supply is required with a stabilized voltage of 12 V, which supply is capable of supplying a maximum current of 50 mA. For safety reasons, it is desired to limit the maximum possible current in case of failures such as a short-circuit in the equipment connected to the supply to at most 200 mA. A supply apparatus according to the invention satisfying these specifications can be used for example to supply current to electrical equipment placed in a gaseous environment presenting explosion hazards as it cannot supply enough energy in the form of heat or sparks to induce explosions. The voltage stabilizer 17 has a voltage loss of 3 V of its own at maximum current, so that the voltage before the stabilizer (with the current limiting resistor 15 being dimensioned properly) then amounts to 15 V. The output voltage V_o of the rectifier 13 should in the first place be equal to the sum of the required voltage (12 V), the voltage loss in the stabilizer (3 V) and the voltage loss at a maximum current consumption of 50 mA in the current limiting resistor, so that

$$V_o = 12 + 3 + 50 \cdot 10^{-3} \cdot R$$
(V_o in Volts, R in Ohms).

The current limiting resistor should further be capable of limiting the current to the above mentioned 200 mA, which means that

$$V_o = 200 \cdot 10^{-3} R.$$

From these two equations follows a value of 100 Ohms for the minimum value R of the current limiting resistor 15, and matching value of the output voltage V_o of the rectifier 13 of 20 V.

For the capacitors 14, 16 and 18, three capacitors of 0.5 μF each may be taken; the ripple will then become smaller than 100 mV. It is important that the self-inductance of the secondary transformer winding does not present a problem, since the number of turns required per volt in a transformer is inversely proportional to frequency, and at the high frequency employed, the required number of turns is small, for instance about 10, so that said self-inductance remains smaller than 1 mH, and is thus considerably smaller than the said 10 mH. Moreover, also the capacity between the windings and the core is extremely small, thus ensuring a high interference suppression of interferences which may be present in the mains.

Figure 2 indicates that the transformer is provided with three secondary circuit panels. The circuit panels shown by the dashed lines indicate that said number may be increased as required, so far as the space available on the core allows this. The invention is not limited to the embodiment indicated in the Figures 2 and 3. For instance, the printed circuit may differ from the illustrated embodiment and the magnetic circuit instead of being rectangular may have some other suitable form.

WHAT WE CLAIM IS:—

1. An electrical power conversion apparatus for feeding one or more separate circuits, comprising a first transformer the primary winding of which can be connected to an alternating current power source of a frequency of 50 or 60 cps a.c. voltage, a rectifier circuit connected to the secondary winding of said first transformer, a generator connected to said rectifier circuit for generating an alternating current having a higher frequency than that of said alternating current power source, and a second transformer the primary winding of which is connected to said generator and having one or several

separate secondary windings, which, or each of which, is connected to a separate second rectifier circuit for providing a direct current output voltage, characterized in that said alternating current having a higher frequency than said alternating power source has a frequency ranging between 20 to 80 kHz., the said second transformer comprises a ferrite loop core having first and second portions located opposite one another, said primary winding of the second transformer being positioned on said first loop portion; and there is at least one printed output circuit which includes a said secondary winding of said second transformer in the form of a spiral disposed in a plane perpendicular to said second loop portion, and which serves to rectify, smooth and stabilise the high frequency current, said output circuit incorporating one or more resistors providing a resistance of at least 100 ohms and having at its output terminals a capacitance and self-inductance of not more than 2 μF and 10 mH respectively.

2. An electrical power conversion apparatus substantially as herein described with reference to the accompanying drawings.

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1 SHEET *This drawing is a reproduction of the Original on a reduced scale*

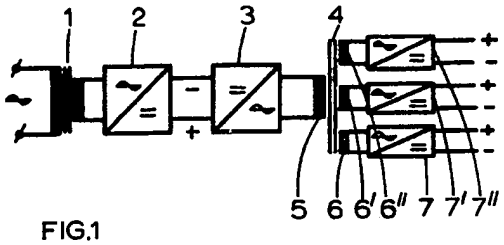

FIG.1

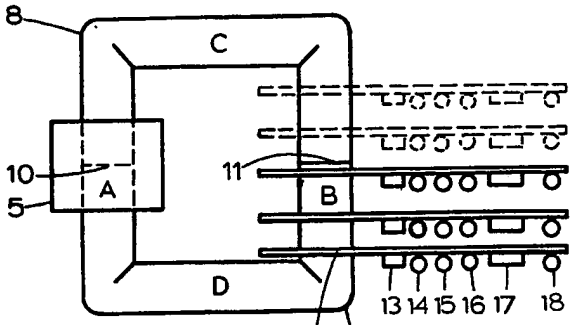

FIG.2

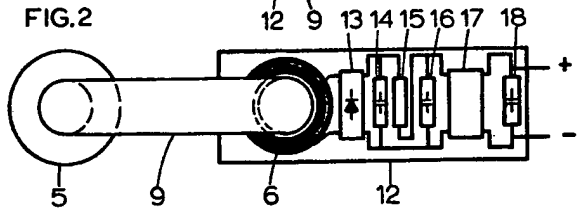

FIG.3